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# TRMM .25º x .25º Gridded Precipitation

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# Text Product

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# *Abstract*

*Since the launch of the Tropical Rainfall Measuring Mission (TRMM), the Precipitation Measurement Missions science team has endeavored to provide TRMM precipitation retrievals in a variety of formats that are more easily usable by the broad science community than the standard Hierarchical Data Format (HDF) in which TRMM data is produced and archived. At the request of users, the Precipitation Processing System (PPS) has developed a .25° x .25° gridded product in an easily used ASCII text format. The entire TRMM mission data has been made available in this format.*

*The paper provides the details of this new precipitation product that is designated with the TRMM designator 3G68.25. The format is packaged into daily files. It provides hourly precipitation information from the TRMM microwave imager (TMI), precipitation radar (PR), and TMI/PR combined rain retrievals. A major advantage of this approach is the inclusion only of rain data, compression when a particular grid has no rain from the PR or combined, and its direct ASCII text format. For those interested only in rain retrievals and whether rain is convection or stratiform, these products provide a huge reduction in the data volume inherent in the standard TRMM products.*

*This paper provides examples of the 3G68 data products and their uses. It also provides information about C tools that can be used to aggregate daily files into larger time samples. In addition, it describes the possibilities inherent in the spatial sampling which allows resampling into coarser spatial sampling.*

*The paper concludes with information about downloading the gridded text data products.*

# Background

Early in the Tropical Rainfall Measuring Mission (TRMM) project, it was decided that basic rainfall data should be made available to the community in a simple format that could be quickly and easily integrated in a wide range of tools. In addition, it was established that the product should contain only the basic rainfall parameters instead of the hundreds of various parameters contained in the standard swath products.

These products would be directly gridded and averaged from the three basic TRMM swath based rain products: 2A12 (TMI rain retrievals), 2A25 (PR rain retrievals) and 2B31 (TMI & PR combined rain retrievals). With his usual sense of humor, the TRMM Project Scientist at the time designated the first of these products as 3G68. "3" for the fact that it was averaged rather than swath. "G" to indicate that the product was gridded. "68" because 12 (from 2A12) plus 25 (from 2A25) plus 31 (from 2B31) is 68.

This initial product was a gridded product using a $.5^{o}$ x $.5^{o}$ grid, at hourly time scale but packaged into daily ASCII text files. A number of scientists requested an additional version of this original product. This new product is described in the following sections.

# Gridded Quarter Degree Basic Description

3G68 is an hourly gridded text product containing TRMM instrument rain estimates. This 3G68 product includes 24 hours of hourly grids into a single daily file. The grid size is .25$^{o}$ x .25$^{o}$.

3G68 contains the following rain information on each data line:

Total pixels from 2A12 (TMI) in cell
Rainy pixels from 2A12 (TMI) in cell
Mean rain rate from 2A12 (TMI) in mm/hr
Percentage of rain from 2A12 (TMI) calculated to be convective

Total pixels from 2A25 (PR) in cell
Rainy pixels from 2A25 (PR) in cell
Mean rain rate from 2A25 (PR) in mm/hr
Percentage of rain from 2A25 (PR) calculated to be convective

Total pixels from 2B31 (Combined) in cell
Rainy pixels from 2B31 (Combined) in cell
Mean rain rate from 2B31 (Combined) in mm/hr
Percentage of rain from 2B31 (Combined) calculated to be convective

All TRMM 3G products report their data on a universal grid where 90°S, 180°W is grid matrix ID (0,0) and 90°N, 180°E is grid matrix ID (360,720). While TRMM data is only collected from approximately 38°S to 38°N, reporting grid IDs based on the universal grid permits easier combination with data from other satellites.

# Detailed Format

The first 5 lines in the file contains header information. Some of these are intended only for visual scanning while other lines can be used by software to assist in setting up memory automatically.

## Header Lines

Line 1:Product_ID (3G68),
Algorithm Version,
Adjustment Algorithm ID (if any applied else NONE)
Adjustment Algorithm Version (if any else NONE)
TRMM Data Credit (NASA/NASDA/CRL)
Date/Time Product Produced (in local time)

Line 2:

Maximum Grid rows (Latitude)
Maximum Grid columns (Longitude)
Minimum Latitude represented in Grid
Minimum Longitude represented in Grid
Grid cell resolution
Date of data in Product

Line 3: (TRMM specific information -- all numeric)

Minimun Latitude for TRMM data
Maximum Latitude for TRMM data
Minimum Longitude for TRMM data
Maximum Longitude for TRMM data

Line 4: keyword identified grid information

Grid_First_Row
Grid_Center_Latitude
Grid_First_Column
Grid_Center_Longitude
Grid_Cell_Resolution

Line 5: Data line column identifications

hour
minute
row
column
tmi_total_pixels
tmi_rain_pixels
tmi_mean_rain
tmi_conv_%
pr_total_pixels
pr_rain_pixels
pr_mean_rain
pr_conv_%
comb_total_pixels
comb_rain_pixels
comb_mean_rain
comb_conv_%

Data Lines

Each data line has a value for each item listed in line 5 of the header. Hour starts at 0 as do minutes. All data item times in this product are presented in UTC. Cell row identification for the hourly grid matrix start at 0 as does the column identification.

In the event that a cell has a value for TMI but no PR pixel in that cell, a 0 is included for pr_total_pixels field but no other values appear for PR or Combined. This situation in essence says that no PR pixel covered that grid box. This approach is taken to keep the file small because it does not print out missing values for the remainder of the PR or Combined fields.

In the event that a cell has no TMI value but does have PR values, the TMI total-pixels field will be set to 0 and rain-pixels set to 0. The mean rain and the convective percentage will be set to -9 to indicate that these are missing.

If neither the TMI nor the PR swath covered an hourly grid box then no information is written to the file. This means that values in the file represent grid boxes that had data from at least 1 of the TRMM instruments. Users may safely assume that grid boxes with no values listed in the file did not contain data.

Sample Data Line

**A**. (Case when there is no PR pixel in cell)

0 5 106 59 24 24 0.87 0 0

This is the first hour grid (zero base) [UTC]. The first pixel in the box was at 5 minute after the hour. The cell is identified by row 106 (zero based) and column 59. This represents the .25° x .25° cell starting at latitude 37°S up to but not including 36.5°S. This represents the .25° x .25° cell starting at longitude 150.25°W to but not including 150°W.

This cell has 24 total pixels. 24 of these pixels were rainy pixels. The mean rain rate is 0.87 mm/hr. In the current product, all convective % values for TMI are 0. This cell has no PR pixels so that no other numbers appear on the line after the 0 for PR total pixels.

**B.** (Case when a line has both TMI data and PR data)

0 10 109 109 48 0 0 0 133 32 0.39 34 133 32 0.35 28

1) This represents data from the first hour (zero based) [UTC]. The first pixel in the box was at 10 minutes after the hour. The cell is identified by row 109, column 109 (zero based). This represents the .25° x .25° cell starting at

latitude 35.5°S up to but not including 35°S and longitude starting at 125.5°W up to but not including 125°W.

**C.** (Case when a line has no TMI data but does have PR data)

2 0 157 196 0 0 -9 -9 33 3 0.04 0 33 3 0.03 0

1) This represents data from the third hour (zero based) [UTC]. The first pixel in the box was at 0 minutes after the hour. The cell is identified by row 157 and column 196 (both zero based). This represents the .25° x .25° cell starting at latitude 11.25°S up to but not including 11°S and longitude starting at 82°W up to but not including 81.25°W.

2) TMI has no pixels in the box. As a result both rain rate and % convective are given the missing value so that user can assume when 0 appears it means 0 mm/hr and is not also used as a missing value indicator.

3) PR 2A25 had 33 total pixels in the cell, 3 of which were rainy. The mean PR rain rate was .04 mm/hr. PR estimated that 0% of the rain-rate was convective.

4) The combined algorithm had 33 total pixels in the cell, 3 of which were rainy. The mean combined rain rate was .03 mm/hr. The combined algorithm estimated that 0% of the rain-rate was convective.

# Rain Mean Calculation

The mean is calculated by summing the rain-rate in the specific product over a cell and then dividing by the total number of pixels in that cell (often known as the unconditioned mean).

$$\text{mean\_rain} = \Sigma(R)/\text{totalpixels}$$

The percent convective rain element is calculated by convective rain rates and dividing by the total rain rate and then multiplying by 100.

$$\text{convective\_percent} = \Sigma(R_{conv})/\Sigma(R) * 100$$

Rain rates are reported with 2 decimal place precision and printed as floating point numbers.

# Matrix Size

The universal matrix (90°S - 90°N and 180°W to 180°E) is used for determining the row and the column values. These row and column values can, therefore, be used directly as subscripts (zero based) into a matrix dimensioned 720 by 1440 (given the .25° x .25° grid box).

TRMM data, however, only use a small portion of this grid. If memory size is a problem, the user can dimension a matrix that is only 320 by 1440 elements for a .25° x .25° grid. The row subscript can still be used for accessing the row of this smaller matrix if 100 is subtracted from the row number provided in the file.

# Combining 3G68 Quarter Degree Files

The Precipitation Processing System (PPS) provides a standalone C program (with documentation) that allows aggregating 3G68 quarter degree hourly files.

Users must have a standard C compiler available. Code may be requested by email to erich.f.stocker@nasa.gov.

Basic operation of program includes the following options:

- will combine all the 3G68 quarter degree files that are located in a directory provided to the program on the command line
- will maintain the hourly entries over the entire combined period (whatever files in the directory)
- or will allow accumulation of all hours into a single line (e.g., an aggregation of all hours of a week, month, year, etc.)
- aggregate only the data where both TMI and PR exist

# Gridded Text Products

| | |
|---|---|
| 3G01-4 | VIRS Channel 4 $T_b$ |
| 3G01-5 | VIRS Channel 5 $T_b$ |
| 3G68 | TMI, PR, and Combined rain at $.5^o$x$.5^o$ hourly grid |
| 3G68.25 | TMI, PR, and Combined rain at $.25^o$x$.25^o$ hourly grid |
| 3G68Land | TMI, PR, and Combined at $.1^o$ x $.1^o$ (South America, Australia, and Africa) |

# Obtaining Products

Anonymous ftp from (email as password). Targeted README files in pub

*trmmopen.gsfc.nasa.gov*

pub/3G68/YYYY/MMM

pub/3G68Land/YYYY/MMM

pub/3G68QuarterDegree/YYYY/MMM

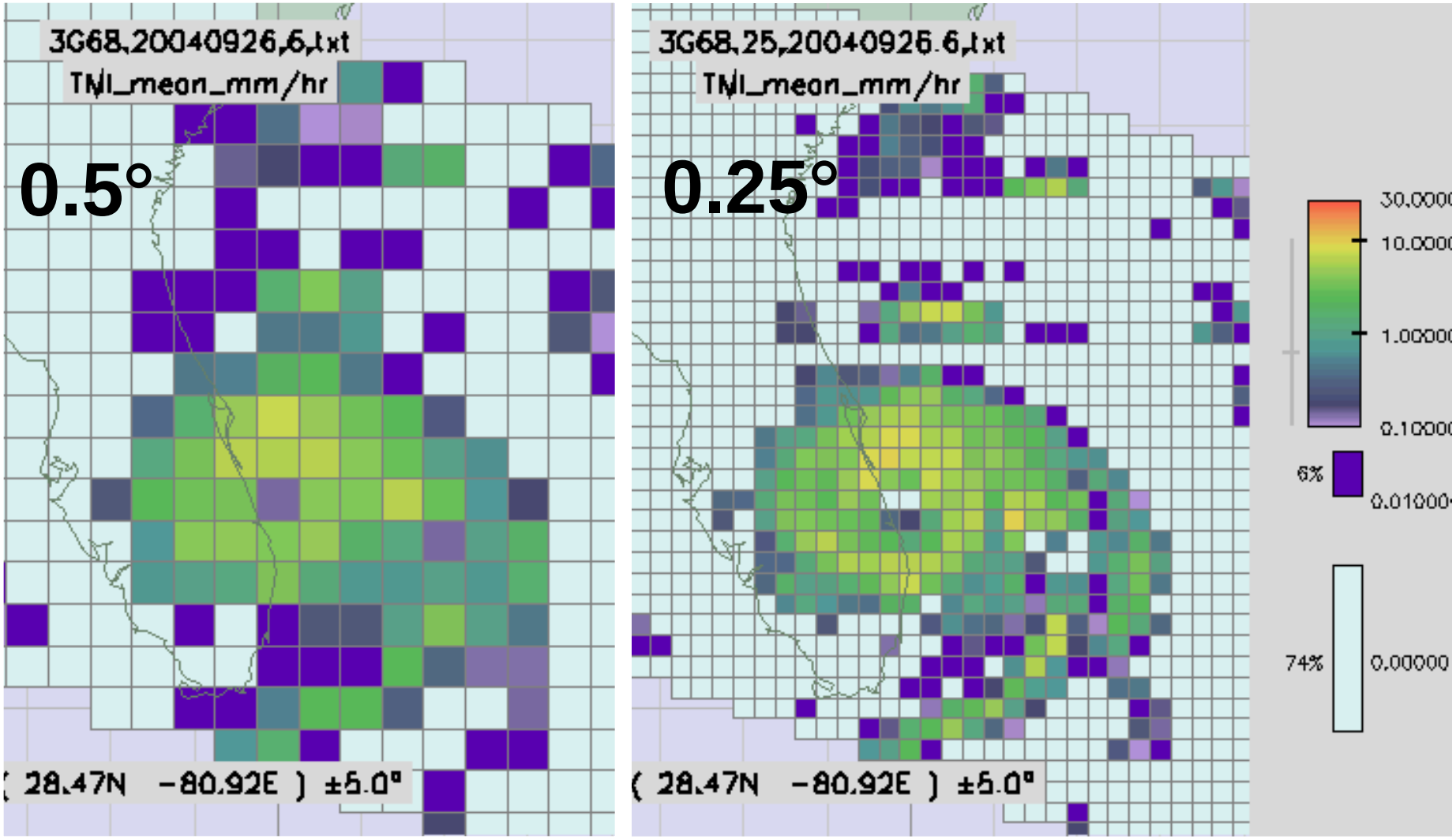
pub/3G01-4/YYYY/MMM

pub/3G01-5/YYYY/MMM

# Hurricane Jeanne (2004)

Hurricane Jeanne was the four hurricane to strike Florida during the 2004 Hurricane season, preceded by Hurricanes Charley, Frances, and Ivan. By the time Jeanne struck Florida, as seen with this 3G68 image, the storm had re-intensified, reaching 110 mph winds, and having a large area covered with heavy rainfall.

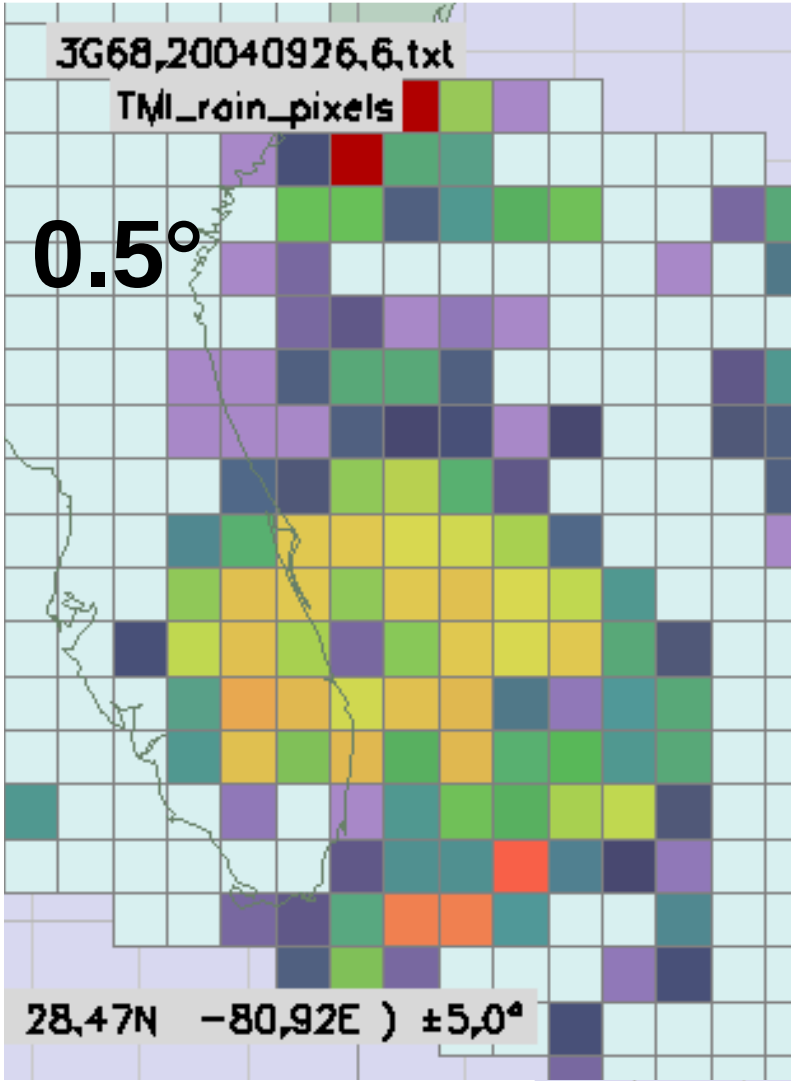
Before making landfall, Hurricane Jeanne had an eventful voyage through the Atlantic. Between September 17 and 18, Jeanne became disorganized due to its collision with Puerto Rico, the Dominican Republic and Haiti, where it left over 1000 people dead. On September 20, Jeanne formed a tight eye, and by September 23, there was a symmetric ring of rain surrounding the eye, which suggested a well organized storm.

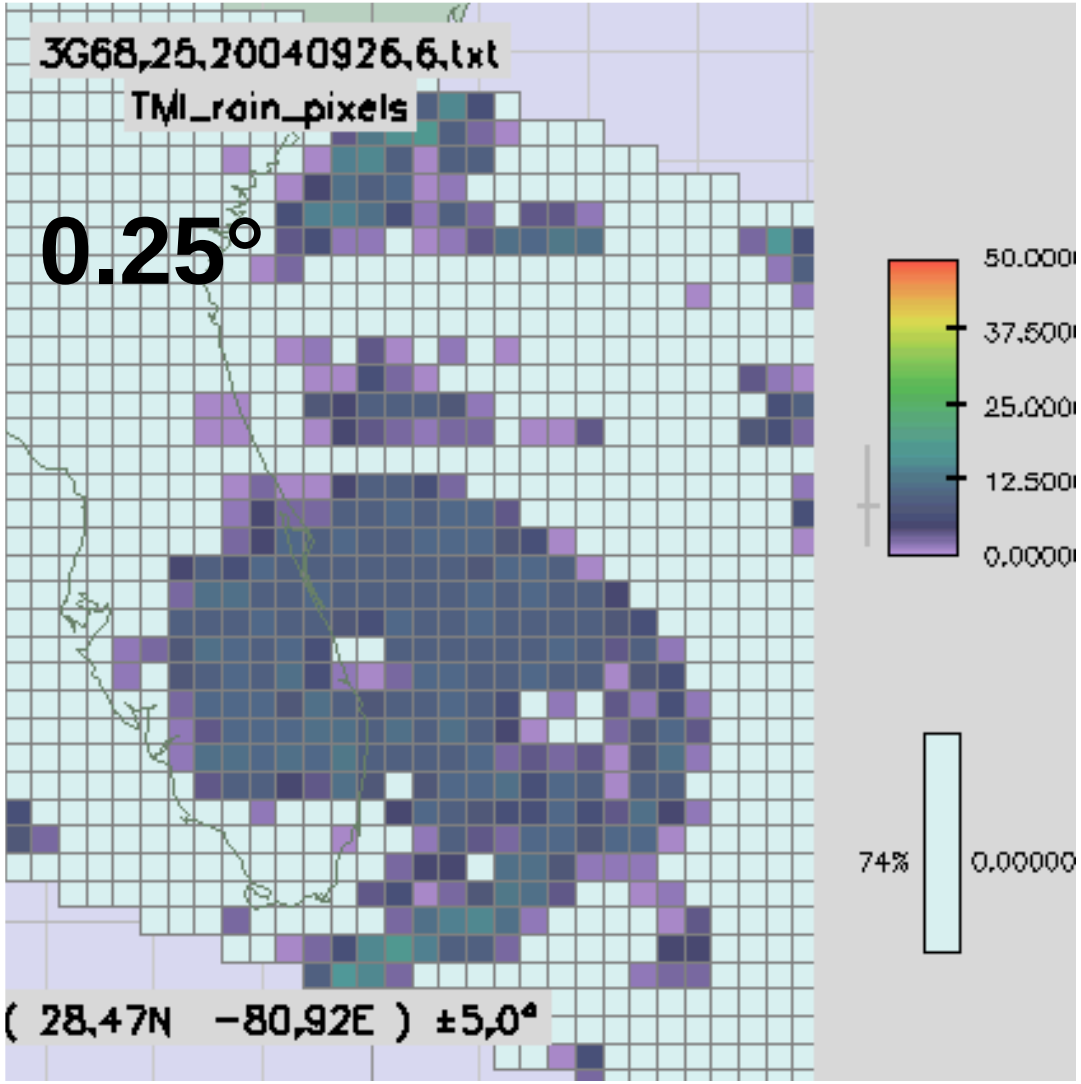



# 3G68 TMI rain rate (mm/h)

# Hurricane Jeanne

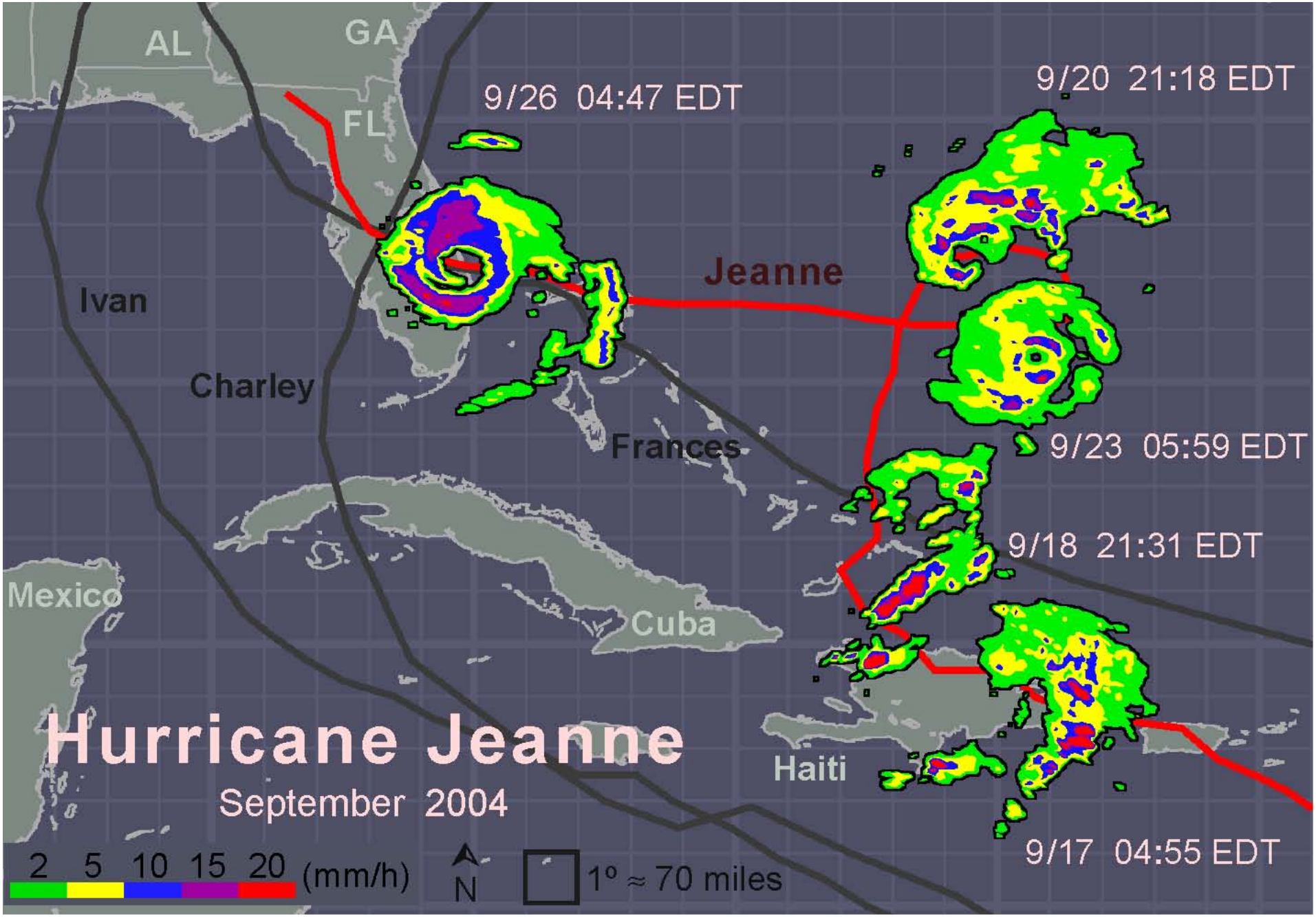
26 Sep 2004, 04 UT, Making landfall over Florida




# 3G68 TMI raining pixels per grid box Hurricane Jeanne

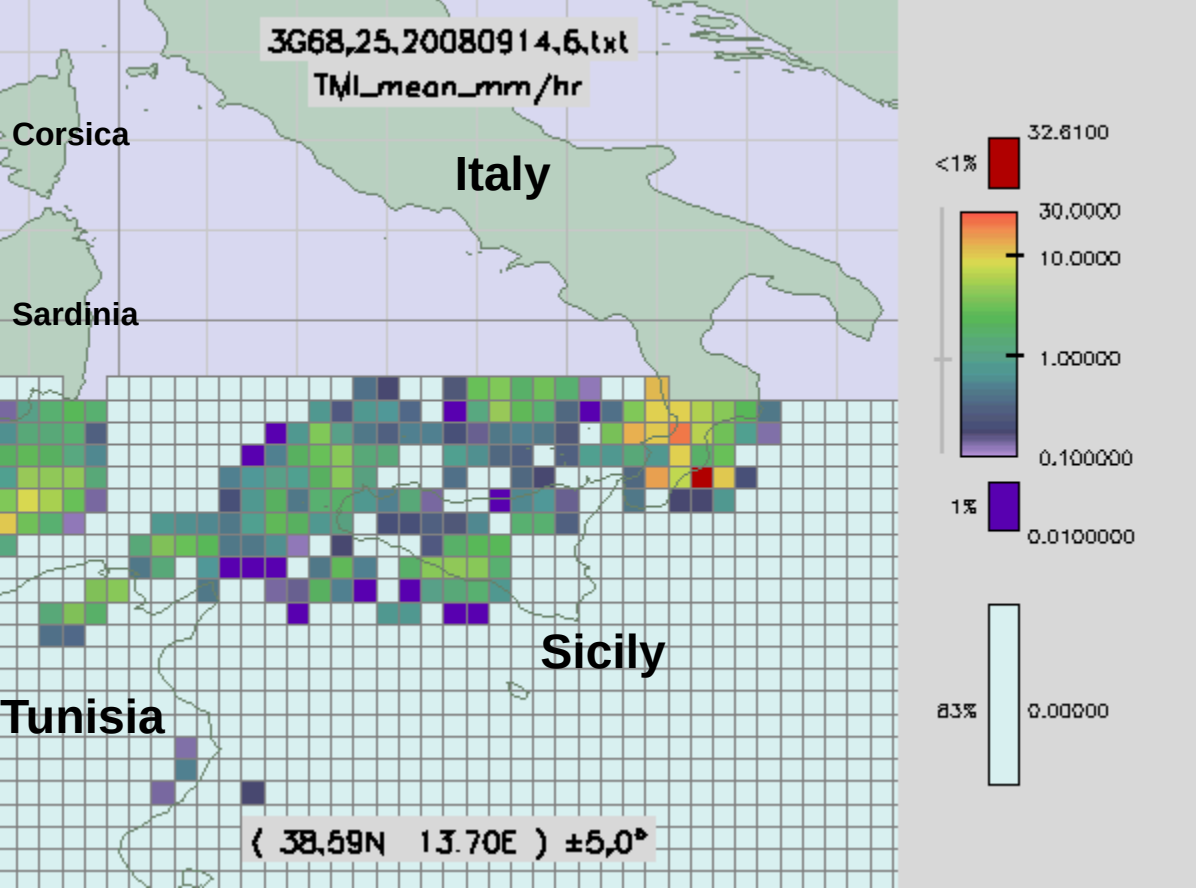
26 Sep 2004, 04 UT, Making landfall over Florida




This image can be downloaded from the following story on NASA's Earth Observatory web site:
http://earthobservatory.nasa.gov/IOTD/view.php?id=4866

# Italian Storm (2008)

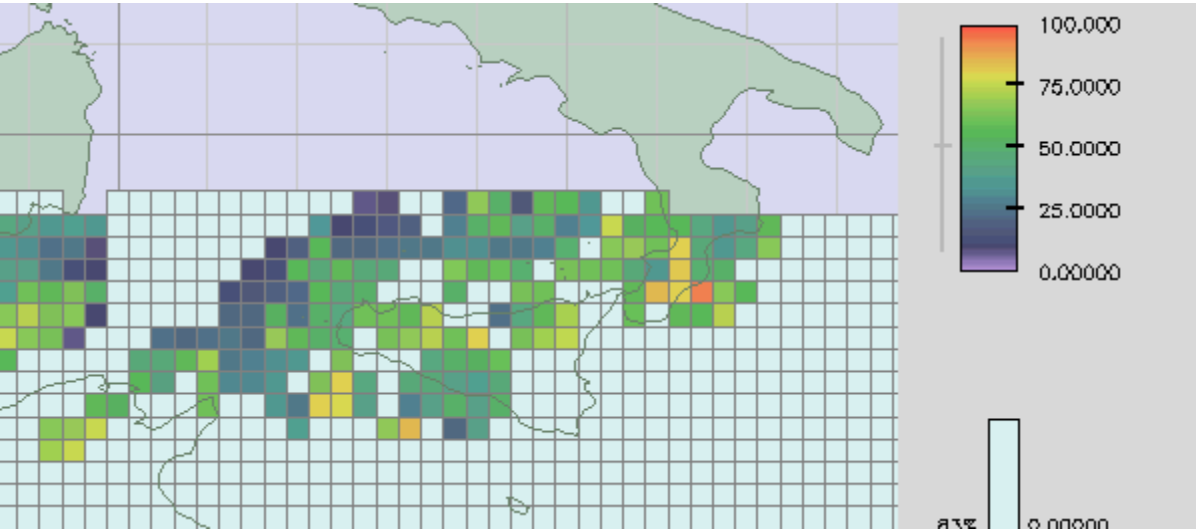
3G68 contains the percentage of precipitation in a particular grid box and hour that falls as convective precipitation vs. the percentage that falls as stratiform rain. The heavest rain typically falls as convective precipitation, as was the case on September 14, 2008, over the southern tip of Italy. The heavest rain exceeded 30 mm/h in a 0.25 degree grid box, and that box was estimated to have over 50% of rain falling as convective precipitation. September is the rainy season for the southern tip of Italy, as can be seen by the time series generated by the TRMM Mission Index. The Mission Index is simply a time series of 3G68 grid boxes displayed by the PPS Orbit Viewer.




# Italian Storm (2008)

38.58°N, 13.70°E
2008/09/14 07 UT

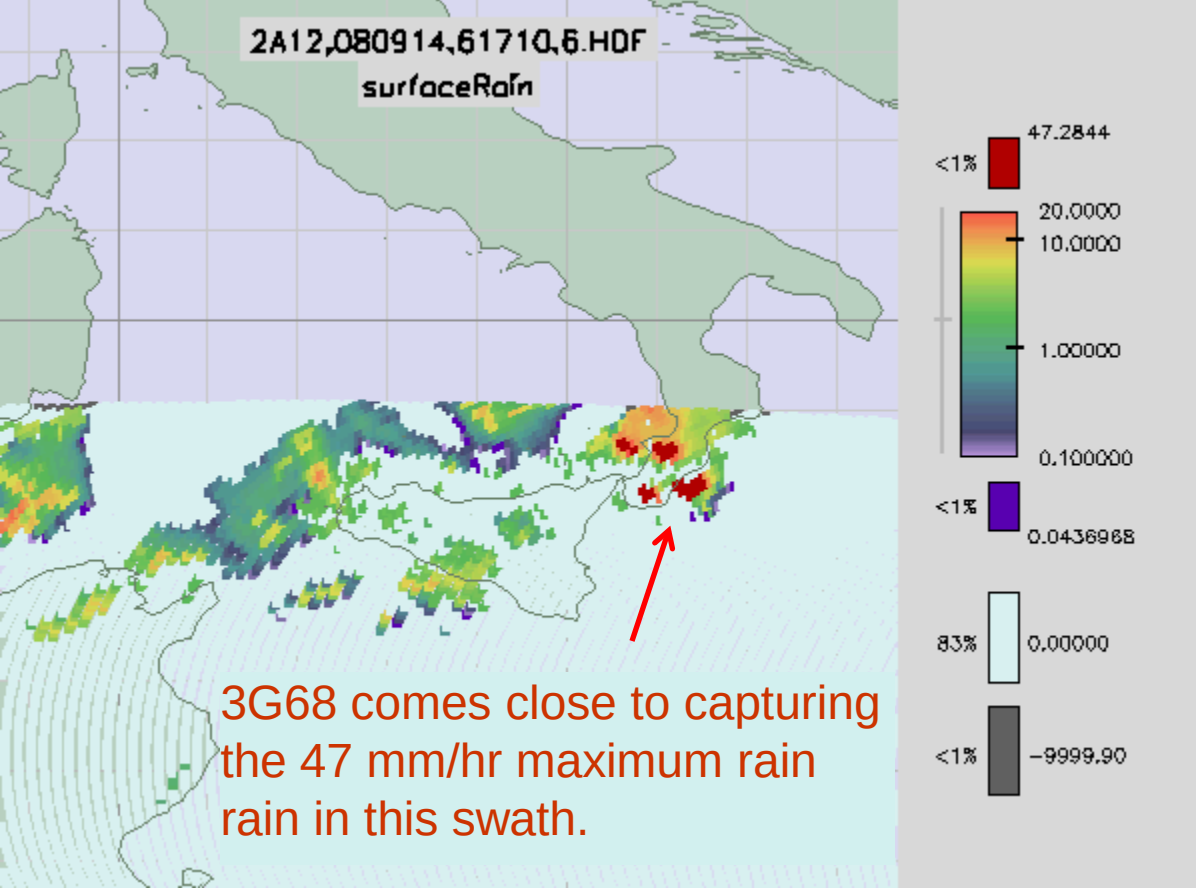
3G68 0.25° TMI rain rate (mm/hr)




3G68 0.25° TMI % of rain falling as convective rain

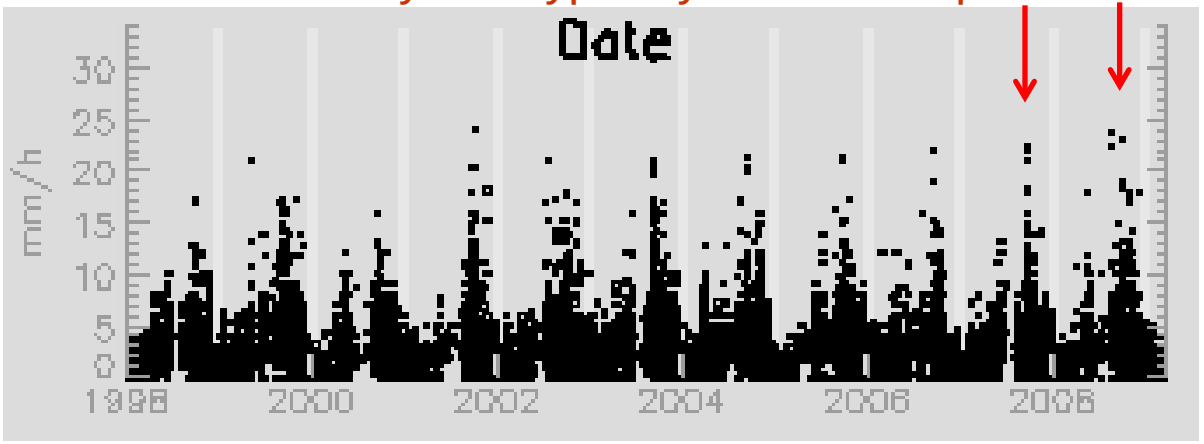
# Italian Storm (2008)

38.58°N, 13.70°E
2008/09/14 07 UT




## TMI 2A12 rain rate (mm/hr)

An index of 3G68 files shows that, in this region, the strongest storms seen by TMI typically occur in September.




## 10 year time series of 0.5° 3G68

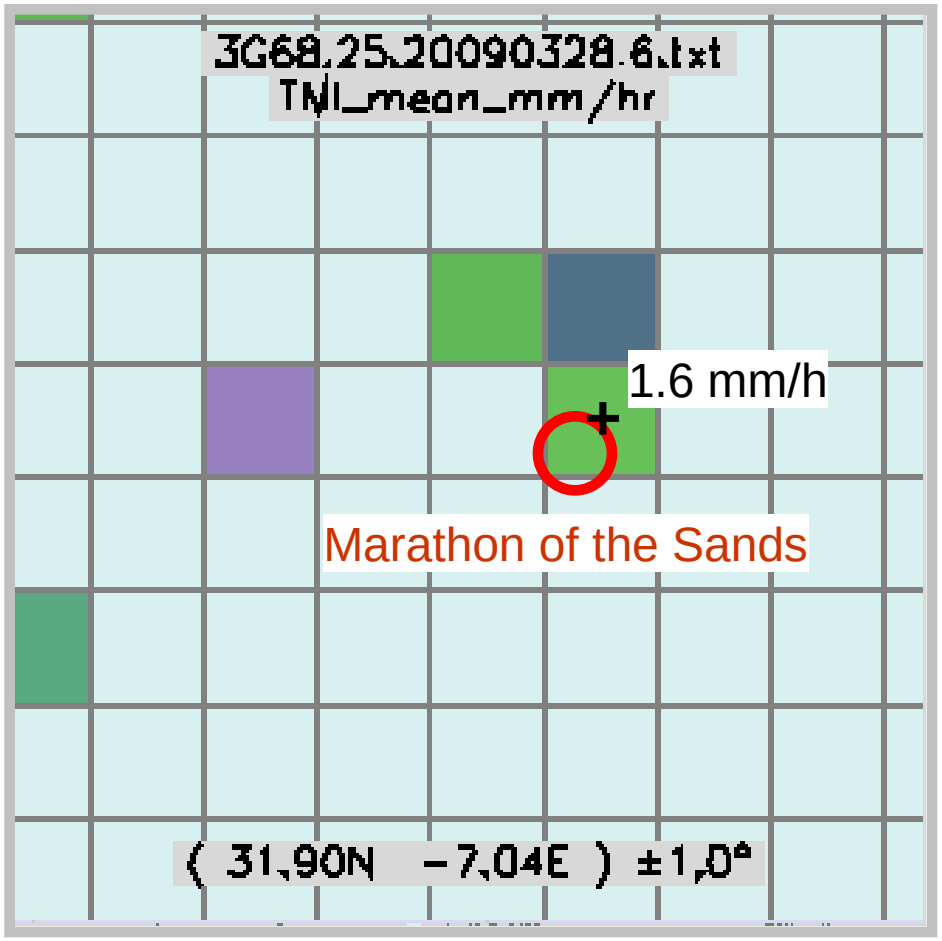
centered on Southern Italy (38.50°N,13.42°E) ±10°

# Rain over the Sahara (2009)

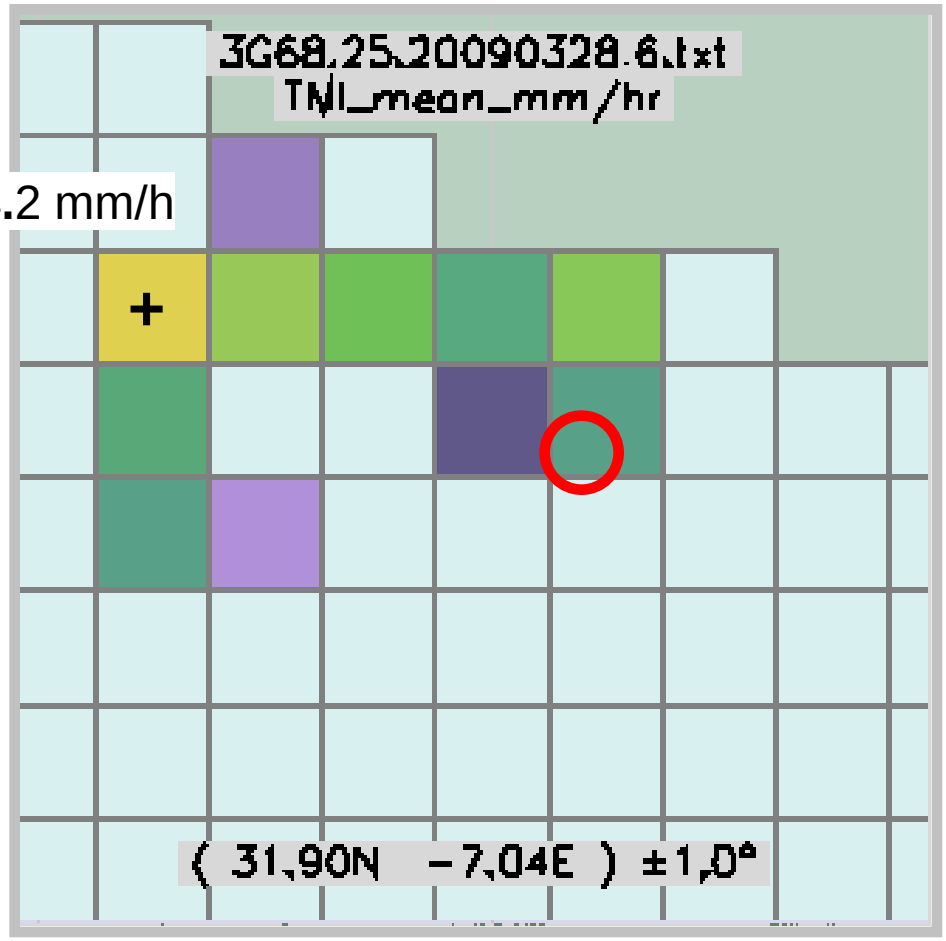
In late March of 2009, there were unusually strong rain cells over Western Sahara (31°N, 6.8°W), which delayed the start of the annual Marathon of the Sands (Marathon des Sables), a foot race of over 100 miles in length. The TRMM Microwave Imager (TMI) did not see any of the storm cells that formed directly over the marathon course. However, TMI did see a number of rain cells in the vicinity of the race over the 36 hour period of the heavy rain. Individual footprints of the TMI instrument estimated rain rates as high as 10 to 13 mm/h. Averaged onto the 3G68 quarter degree grid, the rain rates were 1 to 4 mm/h. The grid box average averages are expected to be lower than the maximum on the original satellite swath because most of the rain rates in each 3G68 grid box are zero rates. An advantage of 3G68 is that individual storm overflights are preserved because of 3G68's one hour time resolution.

*Because of the unusual flooding the first and last segments of the marathon des sables were canceled this year.*

# Storm Cells over Saharan Desert: March 2009

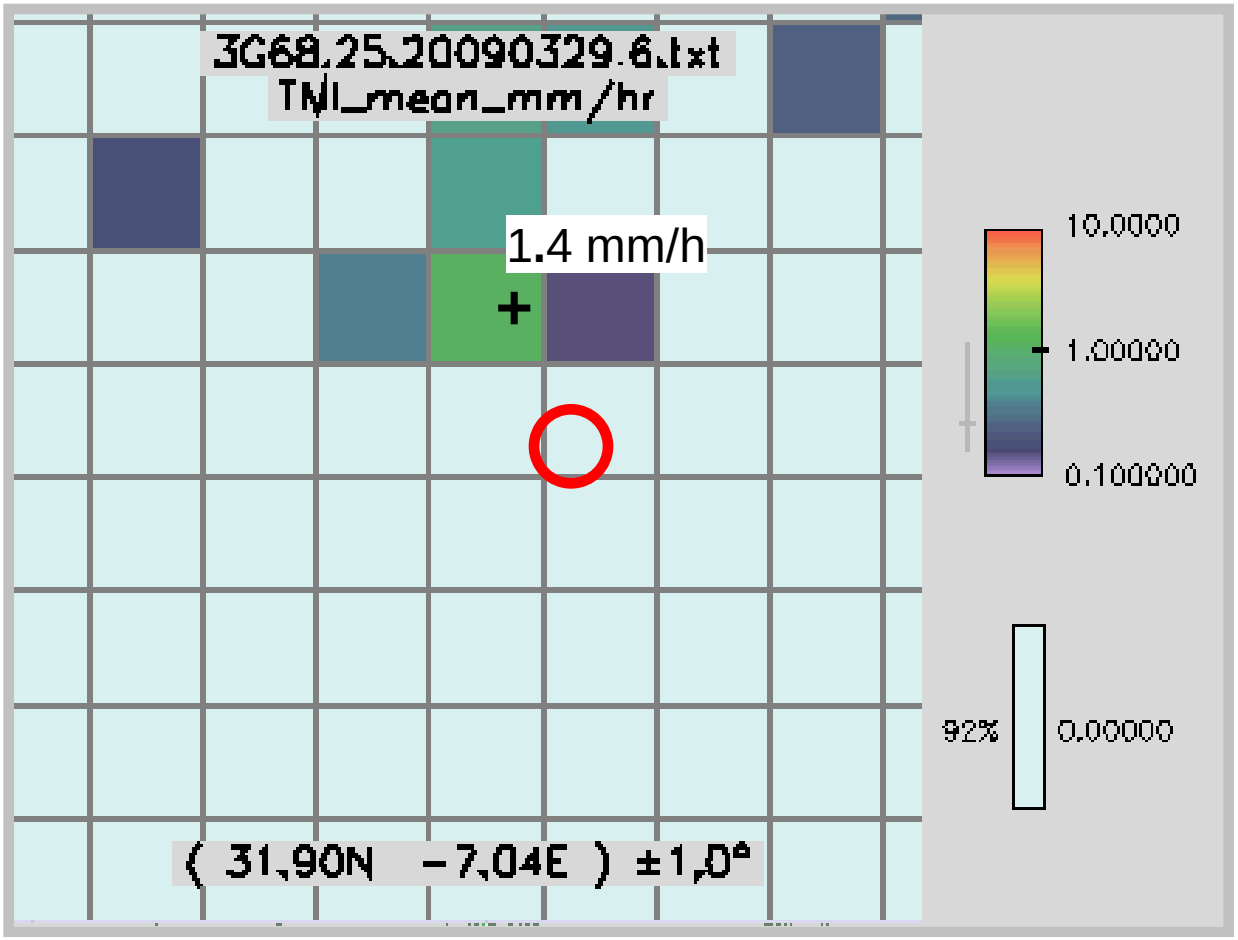



5 UT Saturday
2009/03/28




7 UT Saturday
2009/03/28

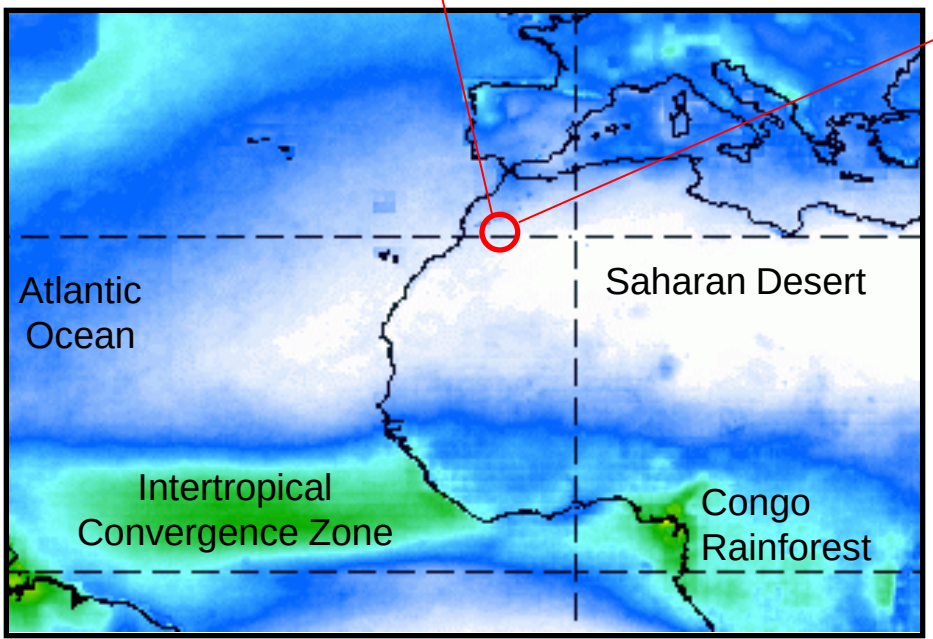
# Storm Cells over Saharan Desert: March 2009 (**continued**)




2 UT Sunday

2009/03/29

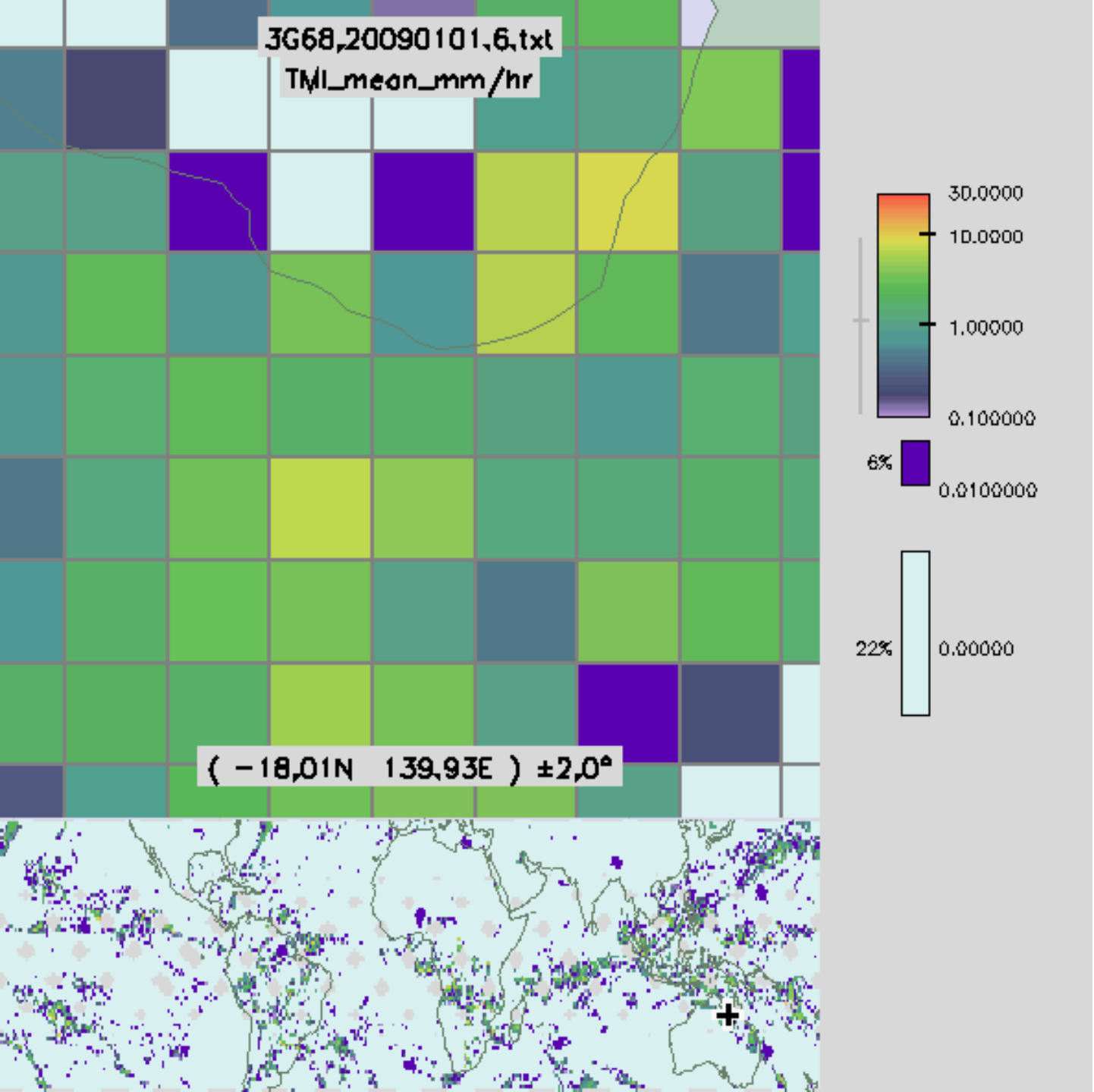
http://www.darbaroud.com/uk/html/mds/24mds/videos/uk_24mds_videos_0329.php
http://www.youtube.com/user/DARBAROUD2009




TRMM-based 10 year rain climatology
(average millimeters of precipitation per day)
http://trmm.gsfc.nasa.gov/

# Australian Monsoon (2009)

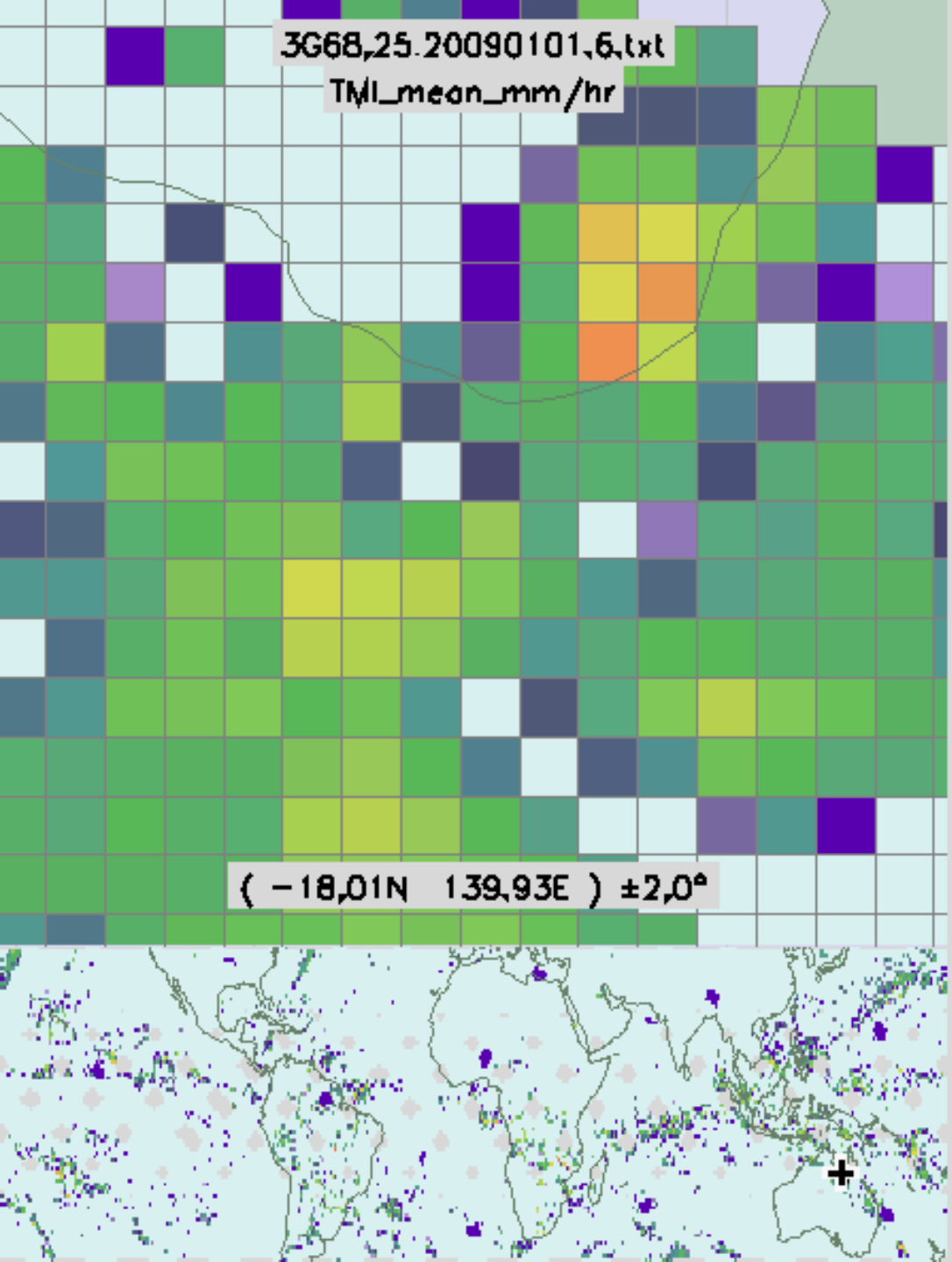
Each January, northern Australian experiences heavy rains as part of its monsoon season.  Due to the El Nino conditions existing in January of 2009, the rains were particularly heavy, bringing floods rather than the expected drought relief.  TRMM-based rainfall accumulations showed in some places 50% more rain than usual during the two weeks ending in the first week of January.




# 3G68
# 0.5°
# TMI
# rain rate
# (mm/h)

# Australia

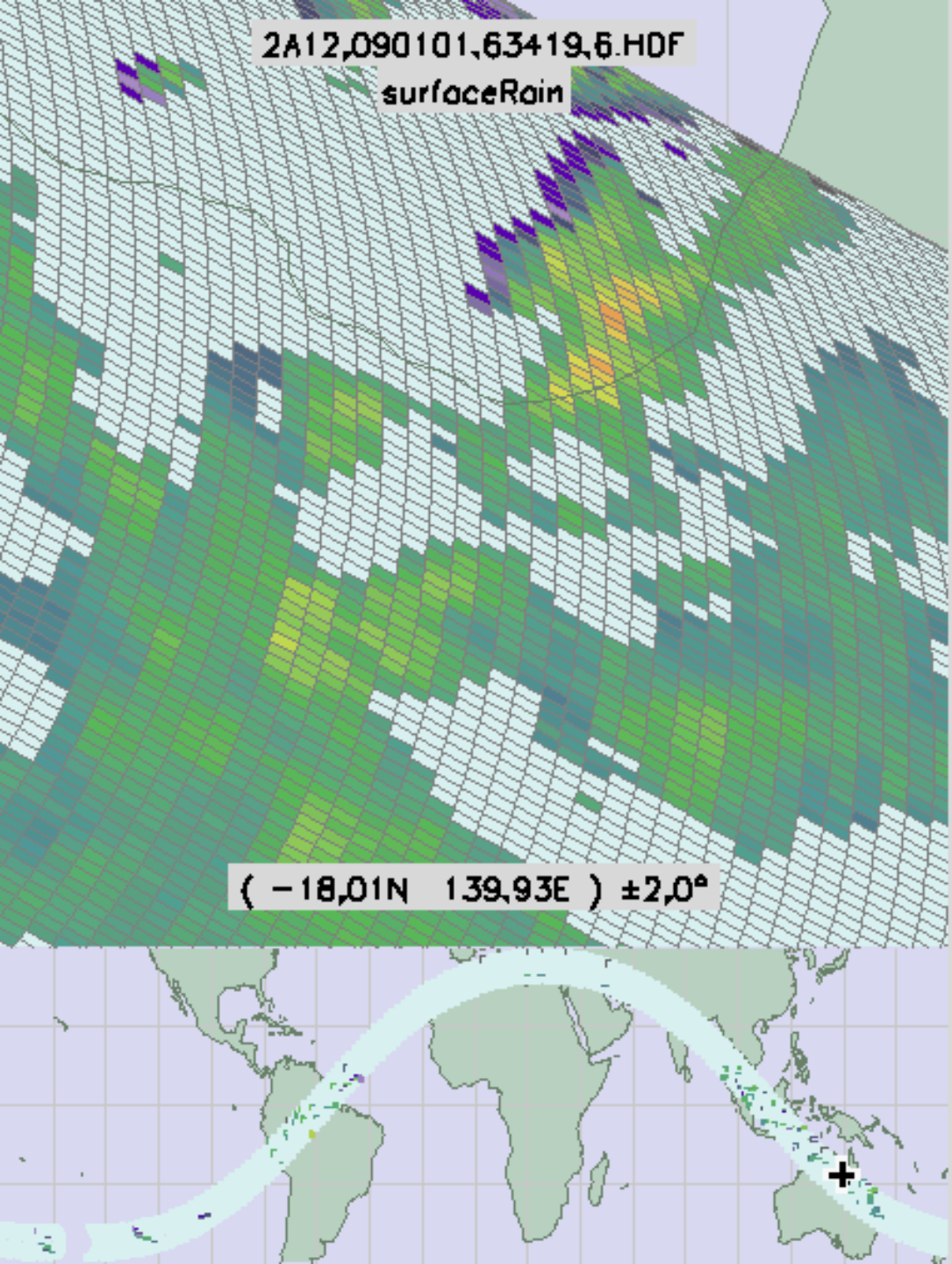
01 Jan 2009
21 UT




# 3G68
# 0.25°
# TMI
# rain rate
# (mm/h)

# Australia

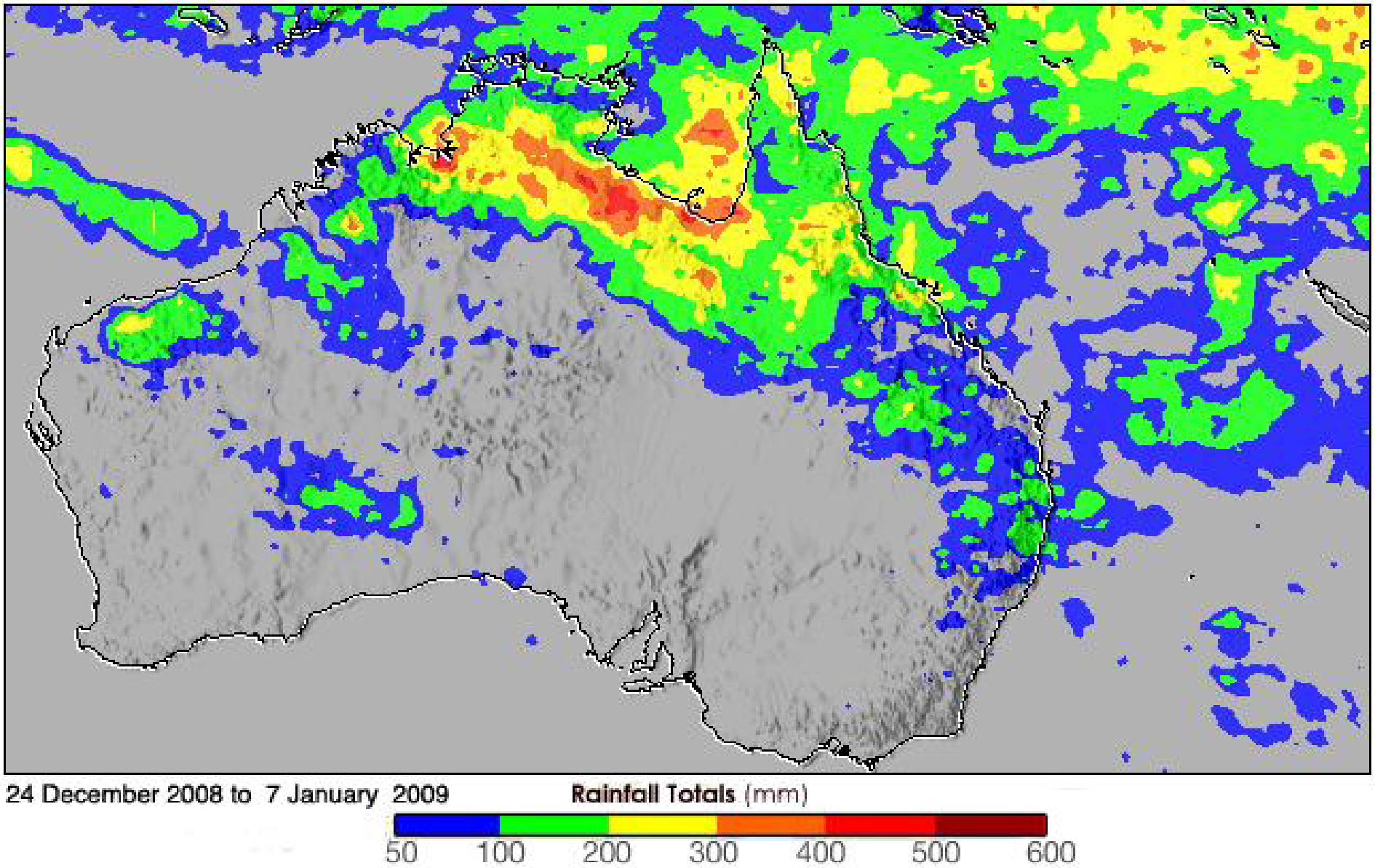
01 Jan 2009
21 UT




# 2A12 TMI swath rain rate (mm/h)

## Australia

01 Jan 2009
21 UT




This image can be downloaded from the following story on NASA's TRMM web site:
http://trmm.gsfc.nasa.gov/publications_dir/australia_flooding_anomaly_dec08jan09.html